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SOME ACCOUNT OF GUNPOWDER.

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VIEW OF THE GUNPOWDER MILLS AT WALTHAM ABBEY, AS THEY APPEARED IN 1735

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SECTION I.

IF the importance attached by the reader to a subject depends upon its extensive use and demand among mankind, *Gunpowder* must be a subject of more than common interest. This extraordinary substance—a powerful weapon in the hands of the conqueror of nations—has for ages decided the fate of mighty kingdoms. As a means of defence, as well as of offence, to armies, it hurls the murdering bullet with force and precision alike tremendous. Nor are its uses confined to war and carnage. It aids the advance of civilization, by becoming in the hands of the miner and engineer a ready means of overcoming the obstacles which are presented to them in their search after mineral treasures, and in procuring materials for building. Immense blocks of stone, for architectural structures, are easily liberated from their quarries by its means; and it removes, by the sudden mechanical force of its explosion, obstacles which impede the progress of the engineer; and so, to a great extent, accelerates the progress of human exertion and industry. The sportsman, too, owes much of his pleasure to this agent, and the multitude manifests its joy on festive occasions by witnessing fireworks prepared by its means. The birth of princes and rulers it announces to the world: it salutes with its thundering voice the approach of those, who are, in common parlance, called *great*. In short, its uses, whether in war, in the arts, in sport, in exhibitions, or in the thunder of its compliments, are so extensive, and so varied, that we cannot wonder at the expression of any desire to add to the knowledge of its uses that of its History and Manufacture.

The invention of gunpowder has been marked as one of those grand epochs in the history of human invention, surpassed only by that of printing and of the steam-engine. It does not belong to our present purpose to trace the effect of this invention in the history of mankind, but we may allude to a common remark, that gunpowder has tended to make war less sanguinary, and to diminish the mere *animal* courage (which perhaps is only a refined term for ferocity and brute force) and the conflict of revengeful passions, so certain to be excited when men meet in close conflict. It has reduced war, in fact, to a science of *tactics*, in the exercise of which skilful management and contrivance are of more avail than personal, individual valour.

There is some doubt as to whether the ancients were acquainted with gunpowder. Virgil, and many of his commentators, and other authors, speak in such a manner of Salmoneus's endeavours to imitate thunder, as to make us think that he used a composition more or less resembling gunpowder. This prince was so expert in mechanics, that his machines imitated the noise of thunder; and the writers of fable state that Jupiter, incensed at the audacity of this prince, slew him with lightning. It has been more naturally, but we know not how correctly, assumed that he fell a victim to some of his own experiments. Dion and Johannes Antiochenus report of the Emperor Caligula that he imitated thunder and lightning by means of machines which at the same time threw out large stones. Themistius states that the Brachmans encountered one another with thunder and lightning, which they had the art of launching from on high at a considerable distance. Agathius reports of Anthemius Traliensis, that, having quarrelled with his neighbour Zeno, the rhetorician, he set fire to the house of the latter with thunder and lightning. Philostratus, speaking of the Indian sages, says that when they were attacked by their enemies, they did not quit the walls to fight them, but repelled and put them to flight with thunder and lightning. He also alleges that Bacchus and Hercules, attempting to assail them in a fort where they were intrenched, were so roughly received by reiterated strokes of thunder and lightning launched upon them from on high by the besieged, that they were obliged to retire. Mythology and history are so blended in the writings of

the ancients, that we know not where to distinguish the poetical from the true. Thus a similar defeat to that which has just been mentioned as having befallen Bacchus and Hercules, was said by the same writer, Philostratus, to have occurred, or was *likely* to occur, to Alexander, who was unwilling to attack the Oxydracæ, (a people inhabiting the country between the Hyphasis and the Ganges) because they were under the protection of the Gods, and hurled thunder and lightning at their enemies. In Julius Africanus there is a receipt for a composition (very much resembling gunpowder) to be thrown upon an enemy.

There are many similar allusions to thunder and lightning scattered throughout the early writers, and there can scarcely be a doubt that some composition, more or less resembling gunpowder, was known in the early ages. That the ancients were really acquainted with some such composition is said to be proved by a clear and positive passage in an author named Marcus Græcus, whose work, in manuscript, is in the royal library of Paris, entitled *Liber Ignium*, (the Book of Fires). The author, describing several ways of encountering an enemy by launching fire upon him, among others gives the following receipt:—"Mix together one pound of live sulphur, two pounds of charcoal of willow, and six of saltpetre; and reduce them to a very fine powder in a marble mortar." He directs a certain quantity of this mixture to be put into a long, narrow, and well-compacted tube or cover, and so discharged into the air. Here we have the description of a rocket. The case or envelope of the instrument with which thunder is imitated he represents as being short and thick, and but half filled with the composition, which is then secured by binding the whole tightly round with packthread: this is exactly the form of the modern cracker. He then treats of different ways of preparing the match, and how one squib may set fire to another in the air, by having the second enclosed within the first. In short, he speaks clearly of the composition and effects of a powder very much resembling the gunpowder of modern times. This author is also spoken of by Mesue, an Arabian physician, who flourished in the beginning of the ninth century.

Nitre, one of the ingredients of gunpowder, was certainly known in remote antiquity. It was discovered in the east, and was known in China and India long before the commencement of the Christian era. Its property as a supporter of combustion must have been noticed by any one who threw a piece of it upon an ignited coal. "Accordingly," as Dr. Thomson remarks, "we find that its use in fire-works was known very early in China and India; though its prodigious expansive power, by which it propels bullets with so great and destructive velocity, is a European invention, posterior to the time of Roger Bacon."

It certainly appears that, whatever knowledge of gunpowder was possessed by the ancients, it was not in general use, and that the introduction of fire-arms is modern. Friar Bacon, who died in 1278, (about three centuries after the time of Marcus Græcus) was in possession of the receipt for making gunpowder; and in his treatise "*De Secretis Operibus Artis et Naturæ, &c.*" he conceals one ingredient of its composition under the veil of an anagram. He writes, "Sed tamen salis petræ, LURU MONE CAP UBRE, et sulphuris: et sic facies tonitrum et coruscationem, si scias artificium." (But nevertheless take of saltpetre, with *powdered charcoal*, and sulphur; and thus you will make thunder and lightning, if you know the mode of preparing it). "Luru mone cap ubre" is altogether unmeaning in that form; but it is the anagram for *carbonum pulvere*, or *powdered charcoal*. This plan of concealing the ingredients of a new composition, or the details of a new process, by the device of an anagram, was very common until about the age of Newton. It appears as if Roger Bacon had been more solicitous to conceal the use of charcoal, than that of the other two ingredients.

Bacon also says, "From saltpetre and other ingredients we are able to form a fire which will burn to any distance;" and again, alluding to its effects, "A small portion of matter, about the size of the thumb, properly disposed, will make a tremendous sound and coruscation, by which cities and armies might be destroyed." Such are the claims of Roger Bacon to this important discovery, which has changed the whole art of war.

Bacon, in another part of his observations, expresses an opinion that it was by the use of something like gunpowder that Gideon defeated the Midianites with only 300 men, (Judges, chap. vii.) Another account states that the Arabians obtained their knowledge of gunpowder from India; and that they employed it in a battle fought near Mecca, so long ago as the year 690. But this is not probable; for the zeal which prompted the followers of Mohammed to propagate his creed by means of the sword, would certainly, had they known the use of gunpowder, have urged them to the employment of a missile so much more powerful than anything previously used. When we consider that the Chinese have been constantly in the habit of constructing rockets, for a period of time beyond all existing records, it seems to imply that whatever might be the case in Europe, the knowledge of some detonating compound has existed for a long series of ages in China. Rockets have likewise been employed as a military weapon by the native Indian armies from a very remote period.

The first mention of the use of gunpowder in Europe, was in a sea-fight between the king of Tunis and the Moorish king of Seville, in the ninth century; when the vessels of the former are said to have had "certain tubes or barrels, with which they threw thunder-bolts of fire." The Venetians made use of gunpowder on the 28th of March, 1380, during a war with the Genoese; and it is recorded that all Italy complained of it, as a manifest contravention of fair warfare. Our Edward the Third employed it at the Battle of Cressy, or Creci, in the year 1346, when he had four pieces of cannon, which contributed not a little to help him to gain the victory. The knowledge of its uses he probably gained from the earls of Salisbury and Derby, who were present at an engagement between the Moors and the Spaniards, at Algesiras, three years before the battle of Cressy.

The Germans claim the honour of the invention of gunpowder for their countryman Berthold Schwartz, a Franciscan friar, who lived at Mayence between 1290 and 1320. He, in some alchemical experiments, had put a mixture of nitre, charcoal, and sulphur, into a mortar, and having accidentally dropped a spark into it, he was astonished to see the pestle fly off into the air. Supposing gunpowder to have been previously known in some parts of the world, it does not follow that Schwartz should have been acquainted with it; it might therefore be perfectly true that, in some of his alchemical researches, he used the ingredients above mentioned, without knowing the value of them as the component parts of an explosive mixture. The instances are by no means few in number in which alchemy—a fallacious and empirical study, considered with regard to its real object—became accidentally the means of eliciting facts and properties, which have since become of immense value to the world.

Our frontispiece represents the gunpowder mills at Waltham Abbey, as they appeared more than a century ago. We have taken the view from a work entitled, "The History of the ancient Town and once famous Abbey of Waltham, in the county of Essex, from the foundation to the present time. London: printed for the author, 1735." The author of this work we find to be "John Farmer, of Waltham Abbey, Gent.," and at page 3 of his work, the following curious observations are made respecting gunpowder.

"Near the town, on one of these rivers, are curious gunpowder mills, which supply the nation with great quantities of gunpowder, being esteemed the largest and compleatest works in *Great Britain* and are now the property of Mr. *John Walton*, a gentleman of known honour and integrity.

"Some suppose this gunpowder to be as ancient as *Archimedes* in *Europe*, (and ancienter in *India*); yet generally men hold the *Friar* of *Mentz*, the first founder thereof, about three hundred and fifty-six years since: in the making of which there requires three essential ingredients.

"1. Brimstone, whose office is to catch fire and flame of a sudden, and convey it to the other two.

"2. Charcoal pulverized, which continueth the fire and quencheth the flame, which otherwise would consume the strength thereof.

"3. Saltpetre, which causeth a windy exhalation, and driveth forth the bullet. This gunpowder is the emblem of politick revenge, for it biteth first and barketh afterwards, the bullet being always at the mark before the report is heard; so that it maketh a noise not by way of warning but of triumph."

We will not enter into the warm discussions which have been carried on—chiefly from a foolish national vanity—respecting the inventor of gunpowder. Students in science have observed, and observing must deplore, the bitter feelings engendered by disputed claims to priority of invention, in the cases of the Differential Calculus, Logarithms, and

many other scientific processes, both in mathematics, and in the sciences more nearly connected with the arts. Such discussions seldom have the desired effect, viz., to convince an opponent. We will therefore pass on to consider the manufacture and general properties of gunpowder.

Gunpowder is a mixture, in various proportions, of nitre, sulphur, and charcoal. Numerous experiments have been made from time to time by scientific men, in order to determine the exact proportion in which these ingredients may be most advantageously mixed; and it is singular that, after many variations, experience has pointed out the proportions adopted several centuries ago, as being the most suitable. So that in this respect, at least, modern science has not assisted in improving the ratio of the ingredients, however much the purity and excellence of the ingredients may have been ensured: it also shows that much care and attention was bestowed upon this important manufacture at an early period.

It is well known that the force of gunpowder is exerted at the very moment only when it is ignited; hence it is clear that this force is due to a sudden expansion produced by the sudden conversion of the solid gunpowder into its constituent gaseous parts, which consist of carbonic acid, carbonic oxide, nitrogen, oxide of nitrogen, sulphuretted hydrogen, and probably aqueous vapour.

As the value of gunpowder depends very much upon the purity of the ingredients which compose it, great care is taken in the preparation of them; and in order to give our readers an opportunity of better appreciating the offices which each one of the three ingredients performs in the compound state of gunpowder, we will devote a short space to each,—nitre, sulphur, and charcoal. In doing this we shall necessarily allude only to those properties or processes, which are more or less connected with the ultimate employment of the ingredients in the manufacture of gunpowder. The varied forms in which they are employed in other manufactures, do not belong to the present subject, and will not therefore be treated of here.

Nitre, or Saltpetre, is the common name applied to a compound of Nitric Acid and Potash, which in chemical language is called *nitrate of potash*. Nitre is abundantly produced in nature, chiefly in the East Indies, Spain, Egypt, the kingdom of Naples, Hungary, and a few other places; but our supply is from the East Indies.

The form in which nitre presents itself, is either as a crystalline product from a rocky formation, or as a vegetable product. It is by reason of the former origin probably, that it has obtained the name of saltpetre—*salpetræ*, (Latin for rock-salt). The most extraordinary source of mineral or rocky nitre is in the kingdom of Naples. There is a deep cavity called the Pulo of Molfetta; in shape something like an inverted cone: the walls of this cavity are of secondary limestone, and a granular crust of nitre or saltpetre lines the whole of the cavity to the thickness of about an inch. When this granular or crystalline crust is scraped off, it is renewed again in a short time by a chemical process going on within the limestone. A similar phenomenon is seen in other parts of the world, but to a much smaller extent: this source of nitre, however, is quite insufficient in a commercial point of view, and can only be regarded as a natural curiosity.

The grand and prolific source of nitre is the vegetable soil. Nearly all vegetable and animal matter contains a small portion of potash in some form or other; and if nitric acid be present, saltpetre is the resulting compound. Now, if we consider that the constituents of nitric acid are the same as those of common atmospheric air, viz. oxygen and nitrogen; and that the wide difference between these two compounds, results from the different proportions in which the two elements are present, and the different energy with which they combine; we shall not find it difficult to conceive that, if by any process the air become decomposed, and its elements made to reunite in another ratio, the acid base which converts potash into nitre may be derived from the atmosphere itself. But not only the atmosphere: many other substances, containing oxygen or nitrogen, or both, may, by decomposition, become the source of the acid base of nitre; and the European mode of procuring nitre (to which we shall presently allude) shows that some such process is going on in the artificial nitre-beds.

The natural nitre-beds of India are plots of ground in which a nitrous efflorescence forms, at certain seasons of the year. This produce is swept off two or three times a week, and again renews itself. The nitrous earth is thus collected and thrown into casks provided with double bottoms, the upper of which is perforated in a number of places. The casks are then filled up with water, and let to remain for about two hours. Valves or cocks, placed in the lower part of the casks, are then opened, and the liquid collected between the two bottoms is drawn off. This process is repeated three or four times; at the end of which the water is found to be saturated with various salts; among which are nitrate of potash (nitre), muriate of potash, and muriate of soda. This liquid (chemically called lixivium *) is then heated, and bullocks' blood introduced, which tends to purify it by bringing up a portion of the extraneous matter to the surface. These impurities are then removed, and the blood made to coagulate, by the addition of a little lime-water, by which means the blood itself can be removed, and the saline liquid is now tolerably free from dirt and other impurities. The blood may also be coagulated by heating the liquid to 150°. It is then boiled several hours, by which boiling the muriates are deposited at the bottom, and can be separated from the rest of the liquid. It is then ladled into a vat where the rest of the extraneous matter subsides; after which it is kept in a close vessel for three or four days, screened from the air and undisturbed. The liquor is then poured away, and the nitre is seen lining the vessel in the form of crystals. It is then fused into cakes, which is the state in which it is sold as rough nitre; and is brought from Bengal in bags, each containing 164 lbs. The highest price paid for this nitre was about 8*l.* 10*s.* per cwt., in 1795; in 1831 it was about 2*l.* per cwt. The quantity imported in 1821, was 244,886 cwt., in 1826, 131,170 cwt., and in 1831, 175,838 cwt. It pays an import duty of 6*d.* per cwt.

The nitre, in the form thus described, although fit for many manufacturing purposes, is not sufficiently pure for gunpowder. One mode of purification is as follows. The nitre is broken into small pieces, and put into a vessel with 20 per cent. of its weight of cold water, where it remains several hours. The water is then let out from a hole in the bottom of the vessel, and carries off such deliquescent salts as may be dissolved in it. Then 10 per cent. more water is poured in, and allowed to stand some time. This is poured away likewise, and a third washing is performed with 5 per cent. of water. After which the nitre is boiled with half its weight of water, and poured into a leaden cooler. As the cooling proceeds, pure crystals of nitre gradually form: these are washed, and again drained to dryness; which is further attained by spreading them out on a large table, and exposing them to a temperature of about 120°: after which they are in a fit state to be placed in the hands of the gunpowder-manufacturer. The number of processes which the nitre is made to undergo, before it is in a fit state to be employed as an ingredient in gunpowder, is sufficiently indicative of the great care bestowed on the preparation of this important article.

We have said that from the East Indies the greatest part of the nitre for British consumption is obtained; and so great is the produce there, that, although the quantity sent to England is so large, more than double that quantity is supposed to find its way to the Chinese market, to be used in the construction of fire-works, in which the Chinese are acknowledged to excel every other nation. This nitrous soil, however, is not confined to the East Indies; for Mr. Bowles has stated that in some of the uncultivated parts of Spain, nitre is so abundant in the soil that, if the land be ploughed to a depth of three or four inches twice or thrice in the spring, and be suffered to lie fallow during the summer, the soil will yield nitre abundantly in the autumn, which may be carted away, and lixiviated in a manner nearly similar to the nitrous earth of India, before described. A similar property, but to a smaller extent, is resident in the soil in some parts of Hungary.

In France and Germany nitre is obtained from artificial nitre-beds, which consist of the refuse of animal and vegetable bodies undergoing putrefaction, mixed with calcareous and other earths. The nitrogen disengaged from the putrescent mass, uniting with the oxygen of the atmosphere, forms the nitric acid, and the potash is probably furnished by the vegetables and the soil. The principal agents necessary for the formation of nitre in this way have been conjectured to be lime, animal and vegetable matter in a state of decomposition, heat, and dry atmospheric air. The mortar from old buildings is generally found to contain a portion either of nitre or of potash, which could be converted into nitre by the presence of nitric acid. Old mortar, therefore, together with decayed vegetables, animal soil, &c., are the

* The Latin for *lye* or *ley*.

principal materials of which the nitre-beds are formed. Nay, to such an extent was the use of such materials carried under the *ancien régime* of France, that an arbitrary law was enacted, to the effect that all such materials might be claimed by the crown, which put the law in force thus: the materials of all old buildings were claimed on the spot; and the soil or earthen floor of every out-house, shed, stable, &c., was dug up once a-year by order of government, that it might be used in the formation of nitre-beds. In some instances the floors of the poorer sort of cottages were dug up for the same purpose. This impost, like many of the French taxes at that time, was farmed out—a sure way to make an oppressive law more oppressive to the subjects of its operation. The annoyance and angry feelings engendered by this practice raised so much discontent that, when Turgot assumed the direction of the finance, he abolished the practice altogether; and the formation of nitre-beds was afterwards conducted without tampering with the property and homes of individuals. Chalk and decayed vegetable and animal matter were mixed together, and saturated with an animal liquid containing a portion of potash, and at the end of two years crude nitre was extracted from the mass, which afterwards underwent many processes, to purify and separate it from the extraneous bodies. But, at the commencement of the revolutionary war, Berthollet, and other eminent chemists, devised modes of preparing it much more expeditiously and perfectly than had been previously known. We shall allude to this in a subsequent part of our subject.

Nitre is rapidly decomposed when mixed with charcoal and subjected to a red heat. Many of the explosions of the alchemists were, no doubt, due to the employment of these two substances, in their endeavours to obtain an acidulated water, called by them *clyssus of nitre*, (a kind of *nitre-wash*,) to which they attributed wonderful medical virtues. These substances they distilled from retorts, luted to capacious receivers, which were generally blown to pieces in the experiments. Mixtures of nitre and charcoal form the bases of a variety of compositions employed for fire-works, the rapidity of the combustion being modified by the relative proportions of the charcoal.

The second ingredient in gunpowder, of which we shall shortly treat, is Sulphur. This is what is called in chemistry an elementary body; that is, no process has ever yet reduced it to a simpler form or state than that which it exhibits as *pure* sulphur. It is inflammable, and fusible at about 220°; brittle, without taste and smell. Its yellow colour is of course known to every one. The pungent stifling smell from ignited sulphur is due to sulphurous acid gas, a compound of sulphur and oxygen.

The native sulphur employed in this country is obtained chiefly from Sicily, where it occurs in beds of a blue clay formation, occupying the central half of the southern coast of Sicily, and extending inwards as far as the district of Etna.

It is also an abundant product in metallic ores, the most available of which is perhaps the copper ore. Large quantities of sulphur are procured from the Paris copper-mine, in the Isle of Anglesea, in North Wales. The copper-ore containing sulphur in a crude state, is placed in a furnace formed of solid masonry, and exposed to an intense heat, which melts the metallic portions of the ore, and drives off the sulphurous portion in the form of vapour, which, passing through a chimney or tube into a brick chamber, subsides, and lines the wall, ceiling, and floor, with an efflorescence, which is removed at intervals of about six weeks. This rough sulphur is of a spongy texture and of a grayish yellow colour, and too impure to be available for the manufacture of gunpowder. To purify this sulphur it is melted in boilers, and all the impurities, which rise to the surface, are skimmed off, after which the sulphur is poured into moulds of a convenient form. The sulphur procured from the copper-ore, however, always contains a small portion of arsenic, which is not the case with the volcanic sulphur, obtained from Sicily, which causes the latter to be preferred in the making of gunpowder.

The quantity imported in 1821 was 113,844 cwt.; in 1826, 251,981 cwt; in 1831, 289,444 cwt. It varies from about 6*s.* to 10*s.* per cwt., and pays a duty of 6*d.* per cwt. in the rough state, 6*s.* per cwt. in a refined state, and 9*s.* 9*d.* per cwt. in the state of flour.

Sulphur is commonly met with in three forms;—1st. massive or crude sulphur; 2nd. roll sulphur; 3rd. sublimed or powdered sulphur, commonly called flowers of sulphur. This latter form is attained by heating solid sulphur sufficiently to raise it to vapour. The vapour, which leaves behind it all the impurities, is collected in large receivers. In this state it is usually contaminated by the presence of sulphurous acid, which, however, may be removed by washing the sulphur in warm water, whereby the resulting sulphur is rendered very pure; since, if a portion of it be gradually heated upon platinum-foil, it will be totally evaporated:—this is a good test of its purity. It is also in its pure state entirely soluble in boiling oil of turpentine. During the wars of Napoleon, when the quantity of gunpowder consumed was immense, great attention was paid to the purifying of the sulphur employed in its manufacture. It was put, in quantities of from ten to twelve cwt. at a time, into iron pots, about three feet in diameter, and two feet deep. The pots were so strongly made, that 1000 tons of sulphur could be melted in each pot, before the united effects of the sulphur and the intense heat rendered them useless. The pots were covered with a sloping roof of masonry, and all the apparatus was calculated to resist the explosive force of heated bodies. The sulphur was boiled in these pots, and all impurities driven off through a tube or chimney communicating with the external air, while only four parts in every hundred of the sulphur were consumed in the process.

The various employments of sulphur in other manufactures—such as sulphuric acid works, &c., do not fall within the scope of our present subject; we will therefore pass on to the last ingredient in the composition of gunpowder.

Charcoal or carbon is, like sulphur, a simple substance. Its purest form is that of the diamond: this is crystallized carbon; and, like ordinary charcoal, is resolvable into carbonic acid, by being burnt in oxygen gas. It also converts iron into steel.

Charcoal is abundantly obtained by the destructive distillation of various animal and vegetable products. A common mode of preparing it in a small way, is to bury pieces of wood in sand, contained within a crucible; to bring the whole to a red or even white heat, which is maintained for an hour or two. Charcoal, thus prepared, is a black, porous, brittle substance. When, however, it is prepared for fuel, billets of young wood are prepared, and formed into a conical pile, which, being covered with earth or clay, is suffered to burn with a limited access of atmospheric air; whereby its reduction to ashes is prevented. The quantity of air admitted is regulated by the management of two holes, one at the top and the other at the bottom of the conical heap. The billets of wood, in pieces of about three feet in length, are arranged in the charring pit, and the heap formed; but, in so doing, two holes are left, one at the bottom, to act as a fire-place, and the other to furnish a draught to kindle the fire. When this is done the upper hole or chimney is closed; and when the wood is thoroughly ignited, the fire-place is stopped up likewise; and so it remains until the wood is completely charred, or converted into charcoal.

Charcoal, thus prepared, is fitted for use in many manufacturing processes; but the purpose which it serves as an ingredient in gunpowder, renders it necessary that it should be purified from many extraneous bodies which unavoidably form part of its substance in the common mode of preparing it. To obviate these objections, and to obtain the charcoal in as pure a state as possible, the wood undergoes a process of distillation; that is, it is subjected to a heat which either liquefies or vaporizes all the foreign matters resident in it, and thus leaves the charcoal or carbon, which no process, either mechanical or chemical, has ever been able to liquefy. The mode of distillation thus employed, is carried on in a large cast-iron cylinder; and to assist the reader's comprehension of the details we will illustrate them by two figures; one of which, (fig. 1), is a section passing along the axis of the cylinder, and the other (fig. 2), a section at right angles to this axis. A is the cast-iron cylinder, about three or three and a half feet in diameter, and five or six feet in length; under which is the fire B, the smoke and heated air from which, C, ascend and surround the cylinder in nearly every part, (as is better seen in fig 2,) and ultimately escape through the chimney D. It will be seen that the cylinder has as few points of support as possible; in order that the flame and heated air may have extensive contact with the cylinder. E is the ash-pit beneath the fire-place; and F and G two pipes or tubes passing through the walls of the building into casks or other vessels placed outside. The whole of these arrangements are set in firm brick-work; and an iron door is fitted to the opening of the cylinder A. Such an arrangement is well calculated for the production of a great heat, and we will now show how that heat is made available for the production of charcoal. The species

Fig. 1.

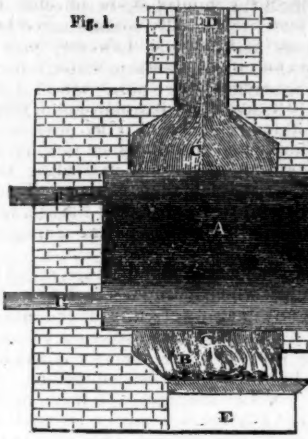
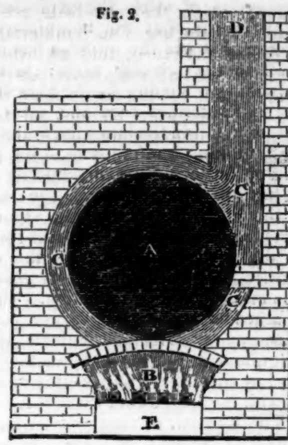


Fig. 2.



CHARCOAL FURNACES.

of young wood selected for the purpose is cut into pieces about nine inches in length, carefully stripped of the bark, and placed in the cylinder, the door of which is then perfectly closed. The heat is then made so intense as to liquefy or else to vaporize all the substances combined with the carbon in the wood; the liquid products escaping through the lower orifice G, and the vaporized substances through the upper orifice F.

Two advantages result from this mode of manufacture. 1st. the charcoal itself is much more pure and valuable, as a component part of gunpowder; and 2nd. the liquid and gaseous products may be preserved in the exterior vessels, and applied to other manufacturing processes. The liquid is *pyroligneous* (*i. e. fire-wood*) acid; which, after being purified from portions of oil and tar, which always distil over with it, becomes acetic acid, the main ingredient in common vinegar; the others being water and colouring matter. Were not the wood in the cylinder carefully excluded from the atmosphere, it would be consumed to ashes by the presence of oxygen; but deprived, as it is, of any constant supply of a supporter of combustion, only a small part of the carbon is lost; the process being really one of *distillation*, rather than of *combustion*.

In some instances the cylinder is double, one sliding within the other; so that when the charcoal in the inner cylinder is completed, the cylinder itself is drawn out, instead of the charcoal only being removed, and another cylinder, supplied with its proper cargo of new wood, is inserted into the already heated external cylinder; by which means much time and fuel are saved.

The selection of the kind of wood, best calculated for the production of charcoal for the gunpowder manufacturer, is a subject which has received much attention. Some woods, such as oak, elm, fir, &c., contain much deliquescent carbonate of potash, which interferes with the purity of the charcoal produced from those woods. Experiments have been made to determine the proportions in which charcoal, produced from various woods, is available as an ingredient in gunpowder; and the following numbers express the comparative merits of five or six species:—Rhamnus frangula, or Black Dogwood=80; Willow=76; Alder=74; Filbert=72; Chestnut and Hazel=66. All other woods have given results inferior to these. So important is the goodness of the charcoal to the ultimate strength of the gunpowder, that with dogwood charcoal, made in a cylinder, the charge for a gun may be one-third smaller than if the gunpowder be made with charcoal obtained by the old method. During the present century plantations of dogwood and alder have been kept up in Kent, Surrey, and Sussex, for the sake of ensuring a good supply of the materials for charcoal for the government powder-manufacture.

The desirable qualities of charcoal, which this manufacture requires, are dryness, lightness, easy pulverization, such as will leave no sensible residue on burning.

Having thus shortly detailed so much of the properties of nitre, sulphur and charcoal, as are concerned in fitting them for being employed in the manufacture of gunpowder, we will proceed to detail the processes of manufacture; previously to which, however, we will treat of the proportions, which have been recommended by different persons, and in different countries, for the composition of the ingredients.

Section II.

There are few compound substances in which the proportion of the component ingredients has varied so much as in gunpowder. The difference of the modes in which the experiments made to determine the most advantageous proportion, have been made—the different qualities of the ingredients employed—and the different purposes to which the gunpowder is to be applied—have probably all contributed to create this diversity. The following shows the proportion in which the ingredients have been chosen in several places.

	Nitre.	*Charcoal.*	*Sulphur.*
England, Royal Mills, at Waltham Abbey	75	15	10
France, proposed by Chaptal	77	14	9
.. .. Beaumé	80	15	5
.. used at present for Ordnance	75	12·5	12·5
.. .. Sporting	78	12	10
.. .. Mining	65	15	20
.. .. Exportation	62	18	20
Prussia	75	12·5	12·5
Austria	76	11·5	19·5
China	75	14·4	9·9

It will be observed that the French employ four different proportions of ingredients for their powder, according as it is required for war, for sporting, for mining, or for exportation. These proportions have been dictated by experience, as the best for those several purposes. It is remarkable that the ordnance proportion is the same as that recommended by Baptista Porta 320 years ago. One of the results of the combustion of gunpowder is sulphurous acid, which has a corrosive action upon the gunlocks; and where it is required to employ guns in long and active service, where few opportunities, probably, occur for dismounting and cleaning, and otherwise repairing these missile engines, and where their perfect action depends upon the clean state of the metal, the source of the corrosive acid, *i. e.* the sulphur, is diminished to a degree not inconsistent with the expansive force of the powder. The increased energy of the explosive force, which depends greatly on the decomposition of the nitre, may be another reason why the proportion of that ingredient is larger in the gunpowder used for artillery, than for the purposes of mining and exportation.

In the second case, as sportsmen generally pride themselves upon the excellence of their arms, and where a certain diminution of the effect due to the sulphur does not militate against the success of the sportsman, a still less portion of sulphur is adopted. In the case of mining powder, where the whole efficacy depends upon the expansive tendency, *i. e.* upon the quantity of gaseous products suddenly liberated, the ingredients are chosen, so as not greatly to interfere with this expansive force; but as immense quantities are employed in mining, attention is paid to the economizing of the ingredients; those for mining-powder being the cheapest proportions of any. There is, besides, another reason for the diminution in the proportion of nitre. It is a well-known law in mechanics, that *time* is an element in all mechanical effects:—that a small force, by acting for a longer time, may produce effects equal to those of a more energetic agent, acting for a shorter space of time. This is shown in the blasting of rocks, where, if the gunpowder

contain a large proportion of nitre, the explosion is very intense, but so instantaneous that the neighbouring portions of rock are shattered before the impulse has had time to communicate itself to the remoter parts: just on the same principle as breaking a window by the blow of a stone or by a pistol bullet: in the former case the glass will be cracked in every direction, but in the latter the bullet will frequently pass through, making a round hole in its passage, but without cracking or shattering the surrounding portions of glass: the bullet has not *time* to produce the same sort of mischief, which the more slowly moving stone would occasion. But (to return to the case of the rock) when the quantity of nitre is diminished, and that of the charcoal increased, the quantity of gaseous matter is greater, but not so intense in the energy of its production. In consequence of this difference of property, a larger portion of rock is shaken and loosened from its hold, without separating or affecting the neighbouring portions so much—which is just the object desired by the miner. Quick-lime or saw-dust may be incorporated with mining powder without much diminishing its effect. The English mining powder frequently contains not more than 60 per cent. of nitre. It has been estimated that the value of 300,000*l.* is expended annually in gunpowder in the mines of Cornwall,—so extensive are the subterranean operations going on in that remarkable and valuable district.

With respect to the fourth kind of powder, that for naval and export purposes, the proportions are further different from another cause, which is probably this. Powder, employed for the navy and for exportation, is necessarily kept for a long time and exposed to much variation of temperature, and to atmospheric moisture. Now gunpowder is never so efficacious as when newly made; and unless kept with much care it absorbs moisture, and the more so in proportion to the quantity of alkali employed: (the alkali is the potash of the nitre,) hence its qualities become greatly deteriorated. For this kind of powder the proportion of alkali is abridged—that being the active agent in promoting deterioration from age, moisture, &c. So far as commercial gunpowder is concerned, there is another and a cogent reason why the proportion of nitre is frequently smaller than in ordnance-powder. Nitre is by far the most expensive ingredient of the three; and is, therefore, the one most liable to adulteration: its place has been in part supplied by other salts; and powder has been sold with so little as 50 per cent. of nitre in it.

In estimating the different purposes to which gunpowder is to be applied, it may be useful to remark that gunpowder containing 19 per cent. of charcoal and 9 per cent. of sulphur has been found to throw a proof-shell to a greater distance than another portion of powder, in which the charcoal was 12, and the sulphur was 12 also.

The French, engaged as they have been in long and active warfare, have from time to time called in the aid of their scientific men, to assist in the preparation of gunpowder. At a time when France was encompassed by foreign armies, which the united powers of Europe had assembled against her,—when a formidable army of French emigrants was assembled at Coblentz, on the Rhine,—when the Austrian and Prussian armies hemmed her in by land,—and the British fleet surrounded her by sea, thus preventing her communication with other nations,—at this time it was suddenly reported to the executive Directory that no more gunpowder was to be had, and that France did not produce the materials for its manufacture! France had for ages been in the habit of importing a large portion of her nitre, her iron, and many other of the implements of war. These supplies being now withheld, it was expected that, thus deprived of all her resources, she would be compelled to submit to any terms imposed upon her by her antagonists. But this was an extraordinary epoch, whether considered with reference to good or evil; and many bursts of mental exertion sprang forth, both in military and scientific proceedings. The French, impatient of foreign aggression, roused to fresh exertion by the imminence of the impending danger, overcame all these obstacles. It was a proud time for French science, which, invoked by its country, fully responded to the call. The names of Berthollet and Monge will be consecrated in the annals of French history, as well as of French science; for it was chiefly due to the zeal, the activity, and the science of those two men that France was not overrun by foreign armies. Berthollet traversed France from one extremity to the other, improved the method of extracting nitre from the soil, (to which we have already alluded), and taught how it was to be practised, and how the nitre could be most expeditiously extracted from the soil and purified. Works were established in every part of France; and gunpowder made in prodigious quantities and in an almost incredibly short space of time. During the second and third years of the republic, every district in France sent two intelligent young men to Paris, making in the whole about 1100, who were instructed by the chemists and scientific men of Paris in the whole process of forming nitre-beds, extracting the nitre, making gunpowder, and founding cannon. These persons were afterwards sent to every part of France, to superintend the establishments set on foot for the management of all these processes.

There was a mode of manufacture, called (from the circumstances under which it originated) the "revolutionary mode;" by which any quantity of gunpowder could be manufactured in about a hundred hours; whereas the time usually employed is two or three weeks. Another plan was also adopted, by which 100 kilogrammes of the "Swiss round powder" could be manufactured in seventeen hours. Berthollet even attempted to form a new species of gunpowder, more powerful than the old, by employing chlorate of potash (a salt which detonates powerfully when mixed with sulphur and rubbed or struck) instead of the nitre. The proportion in which he used it was 80 parts of chlorate of potash, 15 of charcoal, and 5 of sulphur; but after many accidents it was abandoned as dangerous, and too formidable to the friends instead of the enemies of France; for many lives were lost in the experiments performed in using it. It is, however, made at the present day in small quantities, to be used as *priming* for fowling pieces.

We have given these details to the reader from a conviction that twenty-two years of peace, which have been marked by a cheering advance in intellect and intelligence among nearly all classes of society, have contributed to remove those feelings of envy and bitter hatred reciprocally indulged in by two great nations towards each other. The popular prejudice—at one time as firmly entertained as if *Francis Moore, Physician*, had made a prediction of it—that "an Englishman can beat three Frenchmen," has long died away; and the time we hope is come, or is rapidly advancing, when exalted actions, high mental results, and excellence of every kind, will be sufficiently appreciated and admired in our contemporaries, without reference to which shore of the British channel be the land of their birth.

We pass on now to consider the details of the manufacture of gunpowder.

The three ingredients being separately prepared, as before detailed, are separately ground to a fine powder, either by a mill, or by means of a pestle and mortar; and are then mixed intimately together, in one or other of the proportions before described. The mixture is then ground. This operation used to be in England (as it is at the present time in France) performed by means of a pestle and mortar; but less hazard of an explosion is experienced by the employment of a powder-mill; which consists of two circular stones of a calcareous or limestone nature; set up edgeways, and rolling, by means of a shaft, on a bed-stone of the same material, which gives no sparks, as sandstone would be apt to do. The formation of this mill is somewhat similar to that of a Bark-mill, or of an Oil-pressing-mill. Each of the stone rollers weighs about three tons, and they have a double motion, similar to that of a wheel moving round a horizontal circle; that is, the rollers move on their own axes, which are horizontal; and at the same time, but more slowly, move round a circle, which circle is the bed-stone. The two rollers do not follow each other in exactly the same track; but one is nearer to the vertical shaft than the other, and therefore passes over a portion of the bed which was left untouched by the other roller. In some instances metallic rollers have been employed; and would perhaps be the best if care were taken in removing the ground paste from them.

The composition, previously mixed, is spread upon the bed-stone, and moistened with as small a quantity of water as will, in conjunction with the weight of the revolving rollers, bring it into the form of *cake* but not of *paste*. The line of contact between the rollers and the bed-stone is constantly preceded by a scraper, which goes round with the roller, continuously scraping upon the bed-stone, and turning the cake into the track of the rollers. From fifty to sixty pounds of the mixture are usually worked at one time on each mill-stone. The time required to get the ingredients thoroughly incorporated varies with the velocity of the rollers from three to seven hours. The mill is worked

either by wind or water, and therefore varies in its velocity according to the moving power.

The mill-cake (as it is now termed) is then scraped off the bed-stone, which is an operation attended with much danger unless carefully performed. The cake is then sent to the *corning house*, to be converted into corns or grains; previously to which, however, it undergoes a heavy pressure by means of Bramah's hydraulic press, or by a screw press, by which process it is formed into a compact body, nearly as hard as a stone. It is then broken into small lumps, from one to two cubic inches each; after which the *graining* or *corning* is executed by placing these lumps on sieves, on each of which is placed a block of *lignum vitæ*, (a hard species of wood,) shaped something like an orange, that is, in the form of an oblate spheroid. The sieves are made of vellum or of parchment-skins, perforated with a multitude of small round holes. Several such sieves are fixed on a frame, which, by proper machinery, has a horizontal motion given to it, by which all the sieves have a rapid revolving motion given to them at the same time. By this revolution the lignum vitæ block in each sieve moves round with considerable velocity, so as to break the lumps of the cake into very small pieces, and force them through the sieves: thus forming grains of different sizes. These granular particles are afterwards separated from the finer dust by proper sieves and reels, frequently made of silk gauze, to prevent metallic friction.

The granulated powder is now hardened, and the rough edges of the grains rounded off by placing the powder in a cylinder or close cask, which is turned rapidly on its axis. This vessel somewhat resembles a barrel-churn, and should be only half filled at each operation. It has frequently square bars inside, parallel to its axis, to aid the polish by attrition. The barrel or cylinder is so arranged that the powder-dust necessarily produced in this operation is shaken out, and leaves the grains in a smooth clean state, which is all that is necessary for actual practice. But, in order to give the gunpowder used in sporting a degree of *polish*, which is considered as imparting an additional beauty to it, the cylinder is lined with woollen cloth, which, rubbing against the grains as they revolve, gives them a gloss; which operation is called *glazing*. Sometimes a little black lead is introduced into the cylinder to assist in this process. It has been before stated that in France the different objects to which gunpowder is to be applied, determine a slight change in the proportions of the ingredients; but in England the same proportions are used for ordnance, muskets, pistols, and sporting, the only difference being in the size of the grains, and in the fanciful polish given to the latter. The ratio of the sizes of the grains used for ordnance, muskets, and pistols is as 195, 180, and 172. The French sometimes give the grains a spherical form by means of a rolling machine; but the composition is not pressed so hard and firm by that process.

The powder, although it may now seem dry, contains a good deal of moisture, which must be removed before the powder is stored away. This process of *drying* is performed in different ways. In France a body of hot and dry air is let into the drying room, where the damp powder is exposed upon shelves. The general mode in this country, until within a recent period, has been to kindle a large fire or furnace exterior to the drying room; and by that means to heat a large cast iron vessel, called a *gloom*, which is protruded through the wall into the drying room. This gloom is brought to a bright red heat, and thus warms the whole apartment. It has, however, been conjectured that some of the awful explosions, which have taken place at powder-mills, have been occasioned by the workmen accidentally spilling a portion of powder near the intensely-heated gloom, or by currents of air blowing some of the grains against the red-hot surface, or by the same thing happening from the sudden closing of the door of the drying room, as was supposed to be the case at the Dartford mills some years ago. The plan now adopted is infinitely preferable, and consists in passing steam-pipes through the drying room: thus effectually preventing any ill effects; for gunpowder requires a temperature of at least 600° for its ignition. If powder be brought to a high temperature, but not within the sphere of ignition, the sulphur will gradually burn off, without explosion, leaving the nitre and charcoal unburnt.

The *storing* of gunpowder for exportation or for keeping is, like every other part of its management, an operation requiring much attention, in reference to the twofold object of avoiding friction and heat, and excluding the admission of moisture. It is kept in barrels, each containing about one cwt. The barrels are lined with copper, the better to exclude moisture; and to show the extreme care necessary, it has been stated that, on one occasion, a barrel being closed up by cast-iron nails, the roughness of the surface admitted some little grains of powder with them, and the friction, in drawing out the nails, caused an explosion.

The importance of keeping powder in a state of perfect dryness, may be illustrated by an occurrence which took place in the last century. In July, 1779, a naval engagement took place between the French and English, in which the French guns did great execution among the English rigging, &c., while the English guns could not reach the French position at all. An inquiry into the causes of this circumstance was instituted by order of the House of Commons; when it was found that the gunpowder employed had become damp by the moisture of the atmosphere: it had become clotted into lumps, in which the particles of nitre were visible to the naked eye.

When powder has become damp by the atmosphere, it can be rendered fit for use by regrinding, drying, &c.; but when the moisture has too far separated the ingredients from each other, it is of no further use as gunpowder; but the nitre, the most valuable ingredient, may be extracted by soaking the powder in hot distilled water, by which the nitre is dissolved, and the sulphur and charcoal can be removed in the solid state. The liquid being purified and crystallized, may be again employed as nitre for the same manufacture.

In the storing of gunpowder for keeping, a dry airy building should be chosen, removed at least a thousand paces from any habitation, provided with lightning-conductors, and surrounded with walls, ditches, and *chevaux de frise*. There should be a guard constantly set to prevent the introduction of fire, and to hinder all persons from entering, who have articles about them likely to produce sparks. These buildings should contain openings for the free passage of air. The casks of powder should stand upon a platform of wood at a distance from the wall, and the powder itself should be sunned and dried every year or two. If the powder be kept in damp places, as for example in the *casemates* (arched under-ground passages) of fortresses, the internal walls should be covered with lead, and a large vessel of unslaked lime be placed in the middle of the apartment, so that the moisture of the atmosphere may be absorbed by the lime. In the transport of gunpowder the casks are often judiciously packed in sacking, and when so packed they are dipped into melted pitch. Barrels thus prepared have been under water for weeks without injury to their contents.

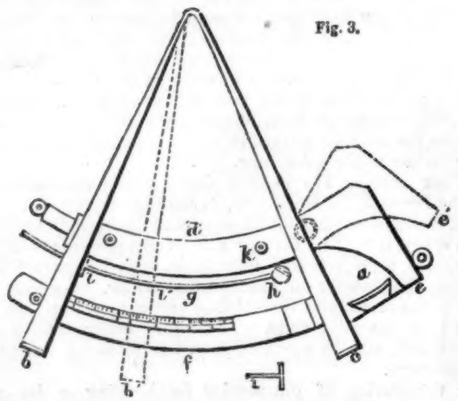
The actual force with which gunpowder begins to en arge its bulk at the moment of explosion has been estimated with extraordinary discrepancy by different individuals, some of whom have derived their estimate from preconceived theories, and others from ill-conducted experiments. The two extreme estimates which we have met with are those of Vernon and of Bracehus; the former of whom estimated the initial impulse at 450 times, and the latter, at 80,000 times, the pressure of the atmosphere. Into such conflicting statements, as to actual intensity of explosion, we will not enter further; but proceed to speak of its real enlargement of bulk, which has been computed to be considerably more than 2000 times its former bulk; that is, the gases into which the explosion reduces the powder, occupy 2000 times the bulk which the solid powder itself occupied.

As the projectile power depends upon this sudden expansion, the excellence of gunpowder is fairly tested by measuring its actual projectile force by means of the *éprouvette*, a French term for any instrument intended to measure or *make trial* of the strength of powder. One form of the éprouvette is a strong barrel, in which a given quantity of powder is fired; and the force of expansion is measured by the action produced on a strong spring or a great weight. The éprouvette now employed in France for testing sporting powder is represented in fig. 3. It is composed of two spring legs *b* and *c*; the leg *c* has at *a* a small reservoir for the powder, together with a pan for the priming. There is also a graduated arc, *f*, which slides in a groove cut in the leg *b*. It has also a metallic wire, *g h i*, which moves through a hole made in the leg *b*: this wire is furnished with a cursor made of skin, which moves by friction. The leg *b* has also an arc *d*, one end of which is bent into a heel *e*, which rests upon the charge of powder.

In order to test the powder, the reservoir, which will hold one gramme, (about 15½ troy grains,) is filled, and the touch pan primed. The sliding cursor is moved to *i*, and the

powder is then fired. At the moment of detonation the reservoir *a*, and the heel *e*, are forcibly separated, each one dragging away the leg to which it is attached, whereby the two legs, *b* and *c*, are brought nearer together; but instantly recoil again by virtue of their spring: the extent of the displacement is, however, indicated by the cursor, *i*, which shows by its new position at *i'*, for instance, that *b* and *e* had been forced into the position *b'* and *e'*: this displacement is measured by degrees engraved on the arc, *f*.

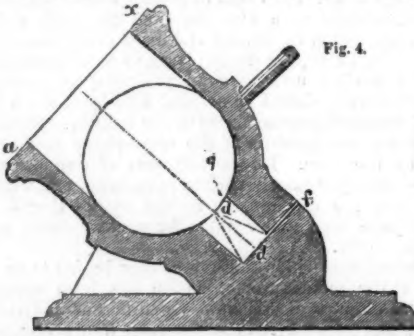
Fig. 3.



Powder for sporting usually marks 12° on this éprouvette, and superfine powder 14°. Each degree represents the effect of one kilogramme of powder, placed so as to bring the two legs nearer together.

The Mortar-éprouvette, or ordnance-mortar of the French, is reserved for assaying the powders used in war. It is composed of a mortar, *a x f*, fig. 4, whose chamber, *d d'*, is

Fig. 4.



sixty-five millimetres deep, and fifty millimetres in diameter. The mouth, *a x*, of the mortar is 191 millimetres in diameter, and the depth 239, from *a x* to *d'*. The bullet, *d*, is 189½ millimetres in diameter, thus leaving a narrow space, called *windage*, between the mortar and the bullet or shell. The vent or touch-hole, *f*, is four millemetres in diameter, and the weight of the copper shell is 293 hectogrammes. The mortar, being inclined at an angle of 45°, is then charged with ninety-two grammes of powder, and fired: when, if the shell be not propelled to a distance of 225 metres, the powder is rejected: good powders carry it as far as 250 or 260 metres.

Another form of éprouvette was devised by the late Dr. Hutton, in which a small cannon was suspended as a pendulum. This cannon was about an inch in diameter at the bore, and was charged with two ounces of powder. The recoil of this little gun, when fired, was measured by a graduated arc attached to the apparatus. Many other forms, one of which is called the *balistic pendulum*, have been devised for the same purpose, with more or less success. Musket-powder is proved by firing at a double target of elm, an inch thick, and previously saturated with water. The depth to which the ball penetrates is a measure of the goodness of the powder.

The details now given will, we hope, furnish the reader with the means of judging of the mode of manufacture, and of the method of testing the purity of gunpowder: we will now say a few words on some of the properties of that singular substance, as determined by experiment.

The theory of the combustion of gunpowder has been much disputed, but without entering into the different theories on this head, we may state as the greatest source of gaseous matter, the decomposition of the nitre, by which the nitrogen is set free in the gaseous state, and the oxygen being attracted by the charcoal converts it into carbonic acid. But this is by no means the only change of state which occurs by the explosion; for a careful analysis of the products of the explosion of 100 grains of powder has been stated in the following form:—

100 grains of powder produced five gases and four solids, viz.:

Nitrogen	13·24 grains, or	42	cubic inches.
Carbonic acid	28·77	30	..
Carburetted Hydrogen	2·70	9	..
Nitrous gas	3.25	6	..
Sulphuretted Hydrogen	2·03	4	..
Subcarbonate of Potash	40		
Sulphate of Potash ..	11		
Carbon	3		
Sulphur	0·5		

Gunpowder however, reduced to its simple elements without explosion, has been stated to consist of Oxygen 31·94, Hydrogen 0·38, Carbon 13·13, Sulphur 10, Nitrogen 7·8, and Potash 36·75.

Powder may be inflamed by a heavy blow with a hammer; the sudden elevation of temperature caused by the percussion is the probable cause. Electricity also ignites it; hence the necessity of lightning-rods, attached to buildings containing any considerable quantity of it. When it is exposed to the action of heat, the results vary with the temperature. If the powder be submitted to the contact of a red-hot body, it suddenly explodes. This is what takes place with the gun-lock: the flint, suddenly striking against the steel of the lock, chips off several minute pieces of the metal, and the heat generated by the percussion fuses the particles, and these fall down red-hot into the gunpowder in the pan, which, instantly communicating with the powder in the barrel, causes the whole to explode. When a gun "misses fire," as it is called, none of these red-hot particles fall into the pan, but about and around it.

Generally speaking, flame will not ignite gunpowder;—a red-hot solid body, as a spark, is necessary. Most of our readers may have noticed that, when a piece of lighted paper is presented to gunpowder, the explosion takes place some little time after the flame is so held to it; whereas the action of a spark is instantaneous. The reason of which is that the flame takes a certain time to raise the grains of powder to a red heat, under which (as before stated) they will not explode; and it is very difficult to bring a flame into contact with a substance placed below it, but powder dropped through a flame explodes the moment it comes in contact with it.

Some of the effects of ignited gunpowder are truly wonderful: when gunpowder is heaped up in the open air and inflamed, there is no report and but little effect produced. A small quantity open and ignited in a room, forces the air outwards, so as to blow out the windows. But the same quantity confined in a bomb within the same room, and ignited, tears in pieces, and sets on fire the whole house. Count Rumford loaded a mortar with one-twentieth of an ounce of powder, and placed upon it a twenty-four pound cannon, weighing 8081 pounds; he then closed up every opening as completely as possible, and fired the charge, which burst the mortar with a tremendous explosion, and lifted up this enormous weight. In another experiment, Count Rumford confined twenty-eight grains of powder in a cylindrical space, which it just filled; and upon being fired, it tore asunder a piece of iron, which would have resisted a strain of 400,000 pounds.

In concluding this paper we may remark that, although it is too much to expect that all the members of the great human family will regard each other with fraternal feelings, and as belonging to one great community, formed to assist and be assisted by each other,—yet we cannot but foster the hope that war (and, in consequence, the destructive employment of gunpowder,) will gradually diminish and yield to knowledge; or, to employ the idea of a distinguished modern writer—that Captain Sword will yield to Captain Pen. The printing-press has done much towards correcting our ideas of true greatness and true power; and we look forward to the same artillery, more than to big brass guns, for maintaining the honour and dignity of a nation.

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